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ABSTRACT

The instructional effectiveness of using an IBM personal computer with an Electrohome Character projector and a flat screen to display instructional material was analyzed with 89 students enrolled in a course on management information systems at McGill University. The lesson used was an introduction to VisiCalc, an applications software package, and consisted of a 15-minute introductory lecture followed by a 70-minute presentation, during which time the microcomputer and display projector were used continuously and classroom lighting was dimmed. The display projected was green on black, and a 40-character-per-line mode was used. Following the presentation, students answered a 22-item, multiple choice questionnaire which covered the topics of seating position and classroom environment, perception of the screen display and its usefulness, prior experience with VisiCalc and computers, and knowledge of materials. Classroom environment and screen display were perceived positively. The media were effective for the class size studied, though room lighting and display design were identified as critical variables: concentrated light sources between the subject and the display should be avoided, as well as use of the extreme fringes of the display area. Six references are listed. (LMM)

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ANALYSIS OF USE OF A MICRO-COMPUTER DRIVEN CLASSROOM DISPLAY

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SUMMARY

This study reports on an analysis of the effects of using an IBM Personal Computer with an Electrohome character projector and a flat screen to display instructional material to a class of ninety MBA students.

The results indicate that this can be an effective medium of communication for a class of this size. Room lighting and display design are critical variables. Lighting should avoid concentrated sources of light between the subject and the display. The display design should avoid use of extreme fringes of the display area.

Subsequent practical experience has confirmed the reliability and transportability of the equipment.

ANALYSIS OF USE OF A MICRO-COMPUTER DRIVEN CLASSROOM DISPLAY

INTRODUCTION

The current generation of micro-computers offers many opportunities for generating displays for use in the classroom. The micro-computer provides:

- -facilities to generate graphics, both with packages and with extensions to existing programming languages such as BASIC,
- -ability to combine graphics with character displays,
- -colour,
- -relative low cost and reliability.

There are three different methods of generating the display in the classroom.

1. Several monitors may be distributed around the classroom, all driven by the one micro-computer. This is the least expensive method. The disadvantages are considerable set-up effort and a clutter of wires and monitors throughout the classroom.

2. A display projector can be connected to the micro-computer to project the images onto a standard screen or a parabolic screen designed to minimize distortion at the edges of the display. This is moderately expensive ($5,000 for black and white) and has the advantages of transportability and ease of set-up.

3. A rear-image projector that projects from behind the classroom onto a display-screen provides the best image. However this is the most expensive method as it requires a specially constructed classroom and usually a dedicated projector fixed in place. Until recently this has been the only practical method for projecting colour displays due to the difficulty of focusing three separate colour images.

Research studies related to classroom use of projected displays have investigated methods for assessing the quality of television pictures [1, 2] and developed recommendation for minimum and maximum viewing distances as a function of display size for both photographic and television images [3, 4, 5]. These studies have not investigated characteristics of computer displays of character data. Recently Powell [6] has reported on an experiment to develop design recommendations for an 80 character per line computer display.

This study reports on results of using a display projector in a fairly large class of approximately ninety students. The objective was to investigate the effectiveness of the medium for instructional purposes in this specific setting and to attempt to identify any possible causes of problems for correction. The study was designed to examine practical classroom use of the

technology and did not attempt to develop optimal measures. The results do, however result in some guidelines of minimum conditions for satisfactory use.

The results were positive, confirming that this technology can be effectively used in a classroom of this size. Environmental room lighting was identified as a critical factor affecting subjects' view of the display. Subsequent use of the equipment throughout the balance of the term established that it is reliable, transportable and easy to set up in the classroom.

METHOD

The subjects were a class of eighty-nine MBA I students enrolled in an introductory Management Information Systems course. The data reported here was collected in the second session of the course.

The topic of the session was an introduction to VisiCalc, an applications software package which is widely-used by managers and business analysts. VisiCalc is designed to be used with a display screen and provides easy-to-use facilities for manipulating data on the display. Only three of the students had heard of VisiCalc, and only one of the three had used it previously.

An IBM Personal Computer was used with an Electrohome display projector. This can be set in either an 80 character per line or 40 character per line mode; the 40 character per line mode was used. The display projected was green on black, and the classroom lighting was dimmed during its use. The classroom had raised horseshoe-shaped seating with a normal capacity of ninety students. Physical characteristics of the classroom are illustrated in Figure 1. Characteristics of the screen display are illustrated in Figure 2.

The session was eighty-five minutes long. The first fifteen minutes were conducted in normal lecture style, introducing the material. The students were told that a questionnaire would be distributed at the end of the class. No students left the classroom prior to the distribution of the questionnaire. During the remaining seventy minutes the micro-computer and display projector were used continuously.

A multiple-choice questionnaire was used, with scoring on mark-sense cards. There were twenty-two questions of the following types:

- -seating position and classroom environment (5 questions),
- -perception of the screen display and its usefulness (8 questions),
- -prior experience with Visicalc and computers (3 questions),
- -knowledge of material (6 questions).

RESULTS

The frequency and percentage of responses to each of the first three sets of questions are shown in Tables 1(a), 1(b) and 1(c). The responses to the 6 questions of knowledge of material were summarized with one mark for each correct question. Table 1(d) indicates the distribution of marks. Some responses to individual questions were either invalid or unreadable by the computer. These responses were simply removed from the analysis, retaining all other valid responses for a subject. This accounts for the variation in the total number of responses to different questions.

The classroom environment was satisfactory, as reported in Table 1(a). Eighty-three per cent of the students reported that their view of the screen was unobstructed (question 3) and ninety-eight per cent of the students reported that their view was either unaffected or only slightly affected by the number of students in the class (question 4). However seventy-five percent would have preferred to have the room dimmer than used or completely dark (question 5).

The subjects' perceptions of the screen display were also positive, although the support was not as strong as for the classroom environment, as shown in Table 1(b). Seventy-six percent could read the screen easily or with little difficulty (question 6) and eighty-six percent found the displays to be useful or extremely useful for learning the material presented (question 11). Fifty-eight per cent considered the displays to be useful for many different subjects while thirty per cent considered the display to be useful only for computer-related subjects or specifically Visicalc (question 12). Difficulties reading the display were attributed to the characters being fuzzy and lacking contrast with the background (question 8, confirmed by question 13), and most subjects, fifty-five per cent, had most difficulty reading the top of the screen.

The lack of prior knowledge of VisiCalc, and limited computer experience are reported in Table 1(c). Eighty-three per cent of the students scored either five or six out of six on the short test of knowledge, as reported in Table 1(d).

ANALYSIS AND DISCUSSION

We were particularly interested in determining if there was any systematic effect of distance from or angle to the screen. Three measures have been used to investigate such effects, question 6 reporting on ease of reading the display, question 11 indicating the subjects' perception of usefulness of the display and the score on the knowledge test. The Chi-squared test has been used to test for significant differences, with cells combined as indicated in the tables to increase cell frequency.

Distance effect.

Table 2 reports on the effect of position in the front, middle and back of the classroom. Due to the classroom shape this provides only an approximation of distance. There is no reported difference on difficulty of reading the display (significance level 0.52) nor on the score on the knowledge test (significance level 0.16).

The analysis indicates a significant effect on perception of usefulness of the display (significance level 0.01). Seven of the twelve students (58%) who perceived the sreen display to be only slightly useful in learning the material were located in the back row. However the same proportion of students in the back row perceived the screen display to be extremely useful (13 of 24 or 54%) as in the front row (12 of 23 or 52%). The effect appears to be a shifting in scale values as more students in the back row shift their classification from "useful" to "slightly useful". Similarly, comparing the middle row students with the front row, there is a shift from "extremely useful" to "useful".

The hypothesis that there is a distance effect is not supported by two of the three measures. The third measure, reported perception of usefulness of the screen display in learning the material, does support an hypothesis of a distance effect. However this measure is not well controlled in that it can be affected by student classroom learning habits or other environmental factors such as local noise or difficulty hearing the instructor (unlikely in this case). Also the effect is primarily a one-category shift on the measurement scale and only 12 subjects (14%) gave a negative rating of "slightly useful". We conclude, therefore, that distance alone does not have an important effect on effectiveness of the display in a classroom of this size.

Angle effect.

Table 3 reports on the effect of the angle of the subject to the screen display. Subjects sitting on the two far sides have been grouped into one category, those in the mid-left and mid-right into a second category, and those in the center form a third category. The same three measures have been used.

The Chi-squared test indicates no effect on usefulness for learning the material (significance level 0.65) nor on the knowledge score (significance level 0.33). There is a significant effect on the difficulty of reading the screen display (significance level 0.02).

To further investigate the angle effect an analysis was made of the interaction of seating angle with subjects reporting difficulty seeing either the left side or the right side of the display (question 7). The hypothesis was that those sitting on the left would have most difficulty seeing the right side of the display, which was at the sharpest angle, with those on the right having most difficulty with the left side. The results, for all subjects, are reported in Table 4. Of the 12 subjects reporting difficulty seeing the right side of the display six were sitting on the right side, while only five were on the left side. Similarly, for those reporting difficulty with the left side of the display, four were sitting on the left, while only two were sitting on the right. This lack of support for the hypothesized effect suggests that the angle effect is mitigated by other environmental or unmeasured factors.

Causes of difficulty reading the display.

To try to identify more precisely the causes of difficulty the subjects reporting considerable difficulty reading the display were analysed separately.

An analysis of several questions that might indicate cause of difficulty is illustrated in Table 5. This compares the responses of those subjects reporting difficulty with all other subjects. An inspection of the table indicates that there was a tendency for more of the subjects reporting difficulty to prefer the room completely dark (Question 5 - 40% versus 18%), and to report that the characters on the display lacked contrast (Question 8 - 69% versus 30%). Also most would prefer to have the projector moved closer to the screen (Question 13 - 60% versus 42%). This suggests some modifications to alleviate the difficulties, particularly to reduce the level of room lighting.

A final analysis was performed to determine the precise location in the room of those subjects reporting difficulty. These subjects were classified both as to angular position and distance, as illustrated in Table 6. This indicates a rather surprising clustering of subjects. On the left side, 6 of the 7 subjects reporting difficulty were in the mid-left section, with 5 subjects in the middle or back rows. On the right side, 7 of

10 were on the far right, in the middle and back rows, while the 3 in the mid-right were in the front or middle rows.

Consideration of this unique clustering led us back to examine the classroom lighting more closely, where we found what we consider to be the cause of most of the reported difficulty. The room lighting is provided by neon lights, and dimming is achieved by selectively turning out some of the fixtures. In the lighting used for this experiment most of the light is provided by fixtures at the back of the classroom. However there are two additional fixtures used.difficulty. One is situated almost directly over the front row on the mid left. We found that sitting directly under the light did not cause us a problem, but when the strong light source was on the periphery of our vision of the screen, as we moved back in the classroom, the distraction was disturbing to the vision. The observed results indicate the same effect.

The other light is, not unexpectedly at the front on the far right. Again, a strong overhead light that is on the periphery of the subject's view of the screen, accounts for the distribution of those reporting difficulty on the right side. No one in the front, far-right, reports difficulty. However those farther back encounter the light source and encounter difficulty. For those subjects in the mid-right section, in the front and middle rows there is still some effect on the upper-right side of the view of the screen, accounting for the reported difficulty. The light source does not effect those in the back row as it is further to the right and apparently at the fringe of their peripheral view.

We therefore conclude that the environmental lighting, specifically the two overhead lights at the front of the classroom have a dominant effect on subjects' difficulties viewing the display. To complete the study we have made detailed measurements of display and classroom lighting conditions as actually used, which are reported in the next section. These measures will suggest minimum, rather than optimal, conditions that can be used.

DISPLAY AND CLASSROOM LIGHTING

Display

The measures of the display lighting were based on spot measures (one degree angle) of contrast at nine locations on the display. The measure of contrast is calculated as the ration of full display light to no display light. The results are illustrated in Figure 3, which indicates the measurements at each location on the display.

To examine the characteristics of the projector one set of measurements was made with the room completely dark. As indicated in Figure 3 the result is a fairly uniform contrast over the whole display area of 9 or 10 to 1. A second set of

measures was made with the room lighting at the level used in the experiment. Contrast falls to a ratio of about 2 to 1. It is also interesting to note that the top and right side of the screen are most affected by the room lighting, where the contrast falls below 2 to 1. This corresponds with the subjects' reported difficulties with the top and right side of the display. A contrast of 2 to 1 would seem to be about the minimum level to avoid difficulty.

Classroom lighting

To examine the classroom lighting, measurements were made of the illumination at desk level at selected locations in the classroom, as illustrated in Figure 4. As we were particularly concerned with the effects of the two overhead lights at the front of the class these measures were made at each row of desks on the mid left and far right. The effect of the overhead light is clearly illustrated by the high levels at the front rows. This effect is not widely dispersed and falls off quickly as we move away from the light source. We emphasize our previous personal observation and study results, that it is not the illumination directly overhead, but rather on the periphery that causes the difficulty in viewing the screen display.

DISSCUSSION

Overall we are convinced that the use of the display projector has been successful in the present experiment. Most of the subjects' difficulties can be attributed to less than ideal environmental lighting, and we were initially unaware of its significance. This experiment was conducted in typical, rather than ideal classroom conditions and provides guidelines on minimum lighting conditions that should be used.

A flat screen, rather than a parabolic screen, was used. This results in some distortion on the corners and fringes of the display. This, together with the low contrast at the top of the screen accounted for the subjects reported difficulty with the top of the screen. This effect was compounded by a characteristic of the Visicalc display. This display has been designed for a single terminal user. It is typical for such designs to use either the top line of the display or the bottom line for prompting and status information; in the case of Visicalc it is the top line. While it is not the most important part of the display it is the one that changes most frequently. As a result the display design uses the weakest part of the display for the greatest activity. This problem will frequently exist when programs that were designed for individual use are used in the classroom. It does suggest that if a program is being developed specifically for classroom rather than individual use, fringe areas of the display should be avoided. Our re-examination of the screen display leaves use satisfied that distortions caused by the flat screen are relatively minor, and do not warrant the cost of the parabolic screen for normal classroom purposes.

CONCLUSIONS

When we were first considering purchase and use of the Electrohome character projector the general assessment of several observers was that it could be used with a class size of twenty-five to a maximum of fifty students. The original intention with the MBA class was to use it with two separate sections of the class. However once the equipment was acquired and it was tested in several classrooms, we decided to use it in the large classroom with all of the students together. The results of this first analysis, together with anecdotal comments of students, confirm this decision. Overall, the results of this experiment are favourable. The significant finding in the study was the importance of environmental lighting.

Previous research of optimal viewing distances and development of classroom design parameters has related distance to the overall display size. Many possible uses of the micro-computer will generate character data, as in this study. As the number of characters per line can vary considerably from one computer to another, or as in the case of the IBM Personal Computer used, can be selected for each application, it would be useful to conduct further research to examine optimal relationships between individual character size and viewing distance, and to identify significant attributes of individual character formats.

Considering the practicality of this equipment, the experience in this and subsequent class sessions has been very favourable. The micro-computer and projector have proven to be as reliable in the classroom as on the desk top, and the equipment can be easily set up in five minutes at the start of each class.

Use of the equipment requires some adaptation. For instance there is still a tendency to want to move over to the display and point to some part of the display in reference to the current discussion. It is much easier to stay sitting at the keyboard and move the cursor around to draw attention to the relevant part of the display. Another important advantage of having a live computer- generated display is the ability to explore "what if" questions immediately in class. There have been several situations in which a student has asked some question and it has been possible to immediately enter changed parameters and display the results.

In summary, the use of computer-generated displays in the classroom appears to be practical, reliable and provides many interesting opportunities for developing new methods of classroom communication.

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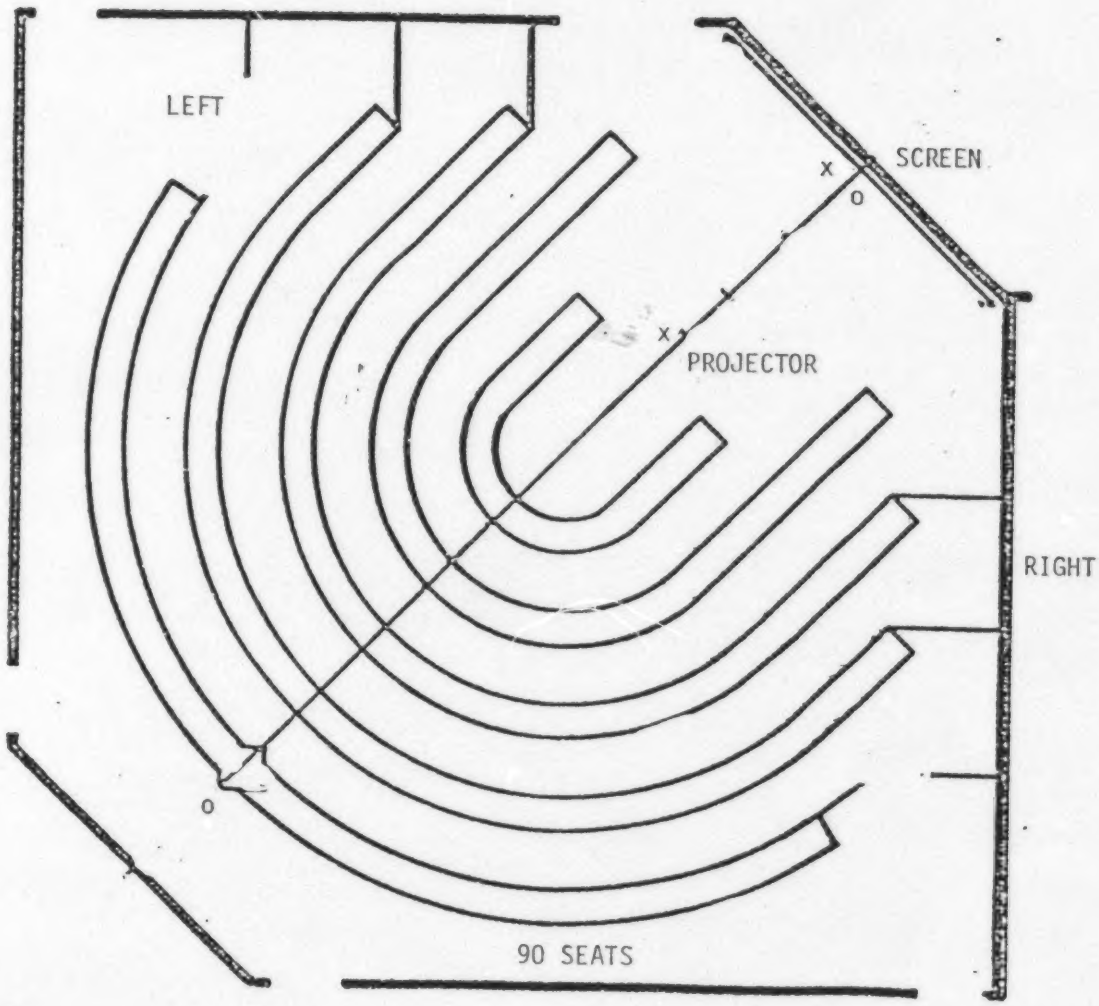
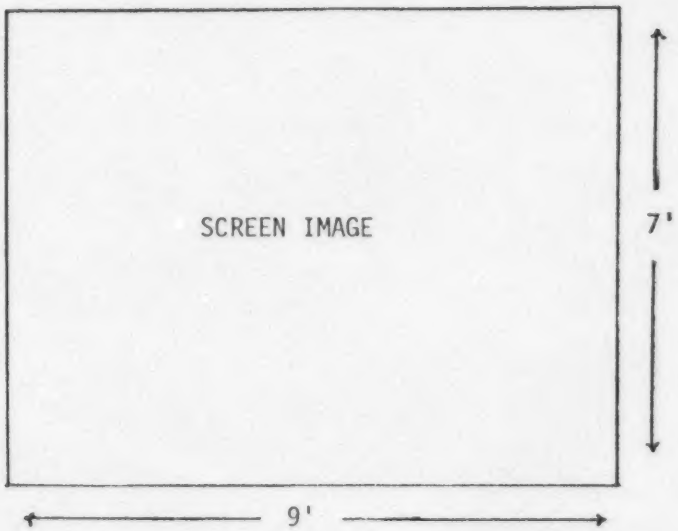
Classroom



x	PROJECTOR-SCREEN DISTANCE	12'
o	MAXIMUM VIEWING DISTANCE	38'
	MINIMUM VIEWING DISTANCE	11'

FIGURE 1. CLASSROOM LAYOUT



CHARACTER SIZE

40 CHAR. ⟵ 2 1/4" ⟶

C 2 3/4"

80 CHAR ⟵ 1" ⟶

C 2 1/2"

FIGURE 2: SCREEN DISPLAY CHARACTERISTICS

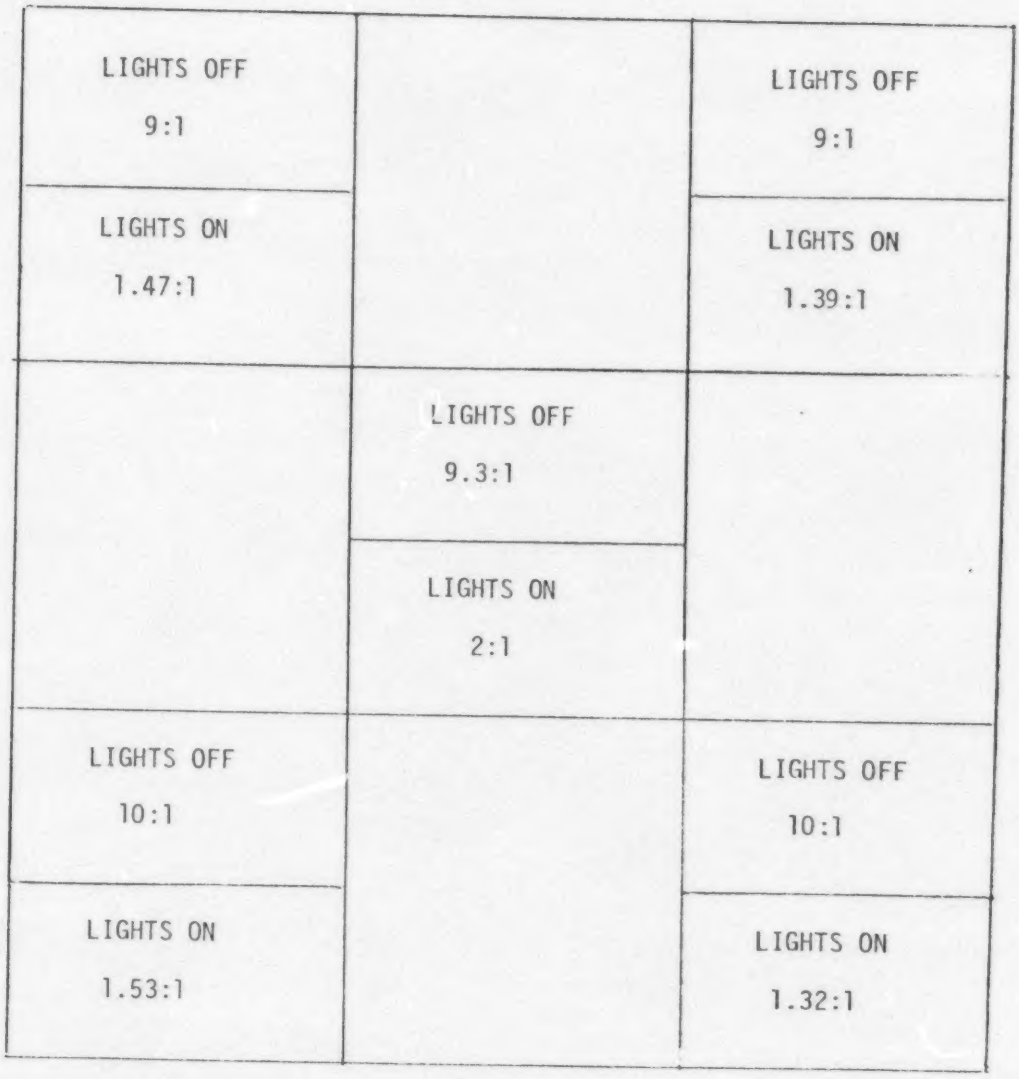


FIGURE 3. CHARACTER PROJECTOR DISPLAY CONTRAST

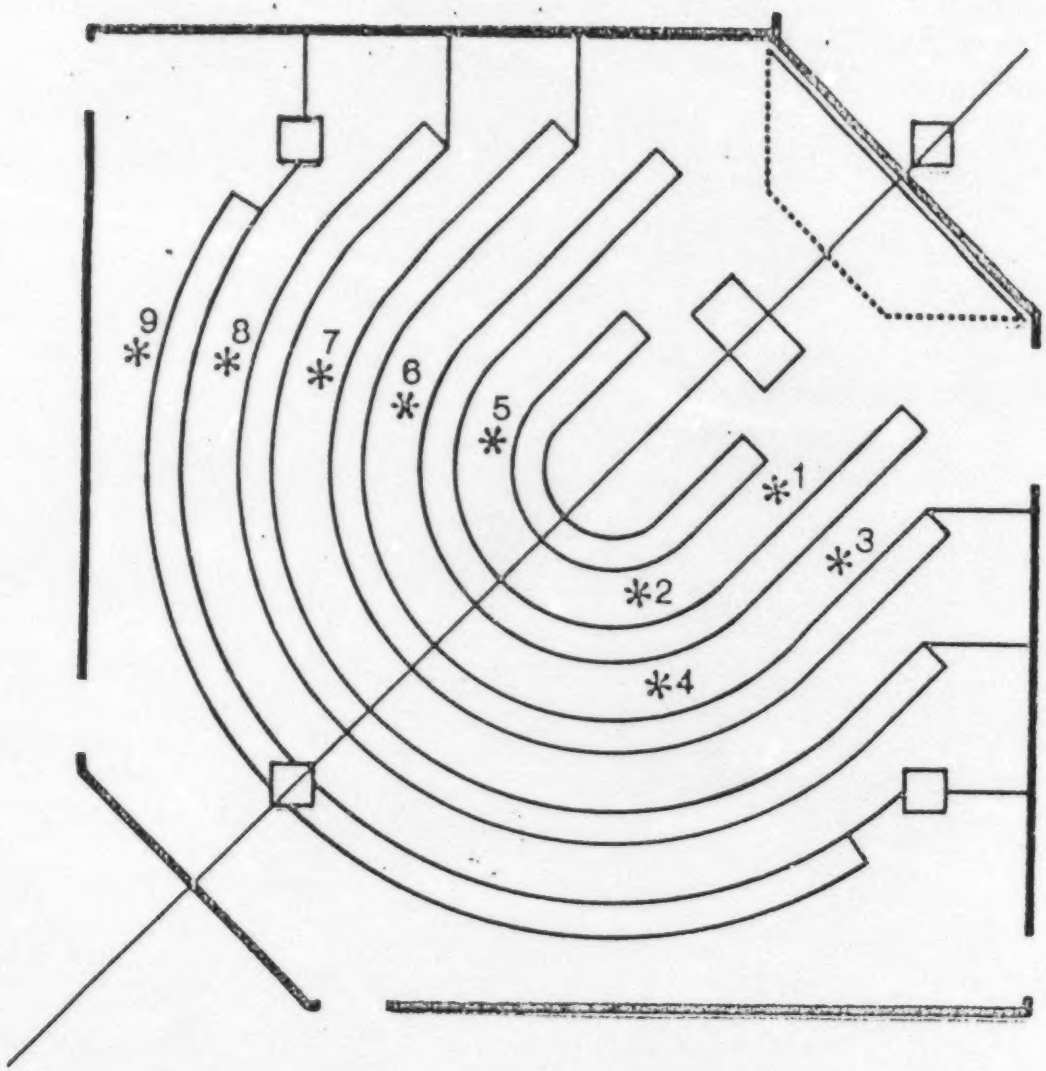


FIGURE 4. CLASSROOM LIGHT LEVELS DURING PROJECTED DISPLAY OF MICRO-COMPUTER

Posn no. *	LIGHT LEVEL(ftc)
1	25 foot candles
2	4 foot candles
3	18 foot candles
4	2.3 foot candles
5	20 foot candles
6	13 foot candles
7	4.3 foot candles
8	2.7 foot candles
9	2.5 foot candles

		N	%
1.	I am sitting		
	1. far right	13	16
	2. right-centre	16	19
	3. centre	26	31
	4. left-centre	22	26
	5. far left	7	8
	Total	84	100
2.	I am sitting in the		
	1. front of the classroom	24	28
	2. middle of the classroom	37	44
	3. back of the classroom	24	28
	Total	85	100
3.	Generally, my view of the screen was (choose one only)		
	1. unobstructed	70	83
	2. obstructed by the projector	4	5
	3. obstructed by the instructor	6	7
	4. obstructed by people in front	4	5
	Total	84	100
4.	Generally my view of the screen was		
	1. unaffected by the number of people in the room	71	82
	2. slightly affected by too many people	14	16
	3. considerably affected by too many people	2	2
	4. seriously affected by too many people	0	0
		87	100
5.	In my opinion, the lighting in the room for use of the display should be		
	1. completely dark	20	23
	2. dimmed to the level used in class	20	23
	3. dimmer than used	45	52
	4. lighter than used	2	2
		87	100

TABLE 1(A). SUMMARY OF RESPONSES - SEATING POSITION AND CLASSROOM ENVIRONMENT

	N	%
6. I could read the screen displays		
1. easily	14	17
2. with little difficulty	48	59
3. with considerable difficulty	17	21
4. hardly ever	3	3
Total	82	100
7. I had most difficulty reading (choose one)		
1. the top	47	55
2. the bottom	8	9
3. the right side	12	14
4. the left side	7	8
5. no significant difficulty	12	14
Total	86	100
8. I had most difficulty because the characters were (choose one)		
1. too fuzzy	37	43
2. too small	3	4
3. lacked contrast with the background	33	39
4. no significant difficulty	12	14
Total	85	100
9. Generally, the screen displays were		
1. changed too quickly	18	21
2. left on too long	1	1
3. left on an appropriate length of time	67	78
Total	86	100
10. Overall, for the whole class period, the projector was used		
1. too much	12	14
2. an appropriate amount of time	70	80
3. too little	5	6
Total	87	100
11. For learning the material presented, the projector displays were		
1. useless	0	0
2. slightly useful	12	14
3. useful	36	42
4. extremely useful	37	44
Total	85	100
12. In my opinion the projector displays could be used effectively		
1. only for the particular subject discussed	5	6
2. only for computer-related material	21	24
3. for many different subjects	50	58
4. for very few subjects	10	12
	86	100

13.	The projector can be moved closer to the screen giving smaller but clearer images, or farther away, giving larger but less clear images. In your option should the projector be moved		
	1. closer to the screen	40	46
	2. farther from the screen	6	7
	3. or left where it was	41	47
	Total	87	100

TABLE 1(B) SUMMARY OF RESPONSES - PERCEPTION OF SCREEN DISPLAY

		N	%
14.	I have		
	1. had no prior knowledge of VISICALC	84	97
	2. seen it but never used it	2	2
	3. used it before	1	1
	Total	87	100
15.	I have		
	1. never used a computer	13	15
	2. used a computer only once or twice	14	16
	3. used a computer a few times	47	55
	4. used a computer extensively	12	14
	Total	86	100
16.	I have		
	1. never used a computer (This is a different question!)	22	26
	2. programmed a computer	21	24
	3. used application programs	13	15
	4. both 2 and 3	30	35
	Total	86	100

TABLE 1(C). SUMMARY OF RESPONSES - PRIOR KNOWLEDGE OF VISICALC AND COMPUTERS

SCORE	N	%
6 out of 6	28	32
5 out of 6	44	51
4 out of 6	11	13
3 out of 6	4	4
	87	100

TABLE 1(D). SUMMARY OF SCORES - KNOWLEDGE OF MATERIAL

		FRONT	MIDDLE	BACK
Q.6	COULD READ SCREEN DISPLAYS			
	easily	5	7	2
	with little difficulty	15	18	15
	with considerable diff.	3	9	6
	CHI-squared	3.2		
	D. F.	4		
	Significance level	0.52		
Q.11	FOR LEARNING THE MATERIAL, THE DISPLAYS WERE			
	slightly useful	2	3	7
	useful	9	21	4
	extremely useful	12	12	13
	CHI-squared	12.99		
	D. F.	4		
	Significance level	0.011		
SCORE				
	6/6	7	14	7
	5/6	15	13	14
	3-4/6	2	10	3
	CHI-squared	6.6		
	D.F	4		
	Significance level	0.16		

TABLE 2. ANALYSIS OF DISTANCE EFFECT

	FAR SIDES	MID-SIDES	CENTER
Q.6 COULD READ SCREEN DISPLAY			
easily	5	5	3
with little difficulty	6	22	18
with considerable diff.	8	11	1
CHI-squared	11.96		
D. F.	4		
Significance level	0.018		
Q.11 FOR LEARNING THE MATERIAL, THE DISPLAYS WERE			
slightly useful	2	4	6
useful	8	16	11
extremely useful	9	17	9
CHI-squared	2.45		
D. F.	4		
Significance level	0.65		
SCORE			
6/6	10	10	8
5/6	6	22	14
3-4/6	4	6	4
CHI-squared	4.61		
D. F.	4		
Significance level	0.33		

TABLE 3. ANALYSIS OF EFFECT OF ANGLE TO THE SCREEN

	SUBJECT LOCATION				
	FAR RIGHT		CENTER		FAR LEFT
	1	2	3	4	5
DIFFICULTY READING RIGHT SIDE (Q.7, response 3, n = 12)	1	5	1	3	2
DIFFICULTY READING LEFT SIDE (Q.7, response 4, n = 7)	2	-	1	3	1

TABLE 4. INTERACTION OF SEATING ANGLE WITH DIFFICULTY READING SIDES OF THE DISPLAY (ALL SUBJECTS)

	CONSIDERABLE DIFFICULTY		LITTLE DIFFICULTY	
	n	%	n	%
Q.1 LOCATION - ANGLE				
far right	7	35	6	9
right	4	20	12	19
center	1	5	25	40
left	7	35	15	23
far left	1	5	6	9
TOTAL	20	100	64	100
Q.2 LOCATION - DISTANCE				
front	3	17	21	31
middle	9	50	28	42
back	6	33	18	27
TOTAL	18	100	67	100
Q.3 VIEW OF SCREEN				
unobstructed	17	89	53	82
obstructed	2	11	12	18
TOTAL	19	100	65	100
Q.4 NUMBER OF PEOPLE IN ROOM				
unaffected	14	70	57	85
slightly affected	5	25	9	13
considerably affected	1	5	1	2
TOTAL	20	100	67	100
Q.5 PREFERRED LIGHTING				
completely dark	8	40	12	18
dimmer than used	10	50	35	52
as used or lighter	2	10	20	30
TOTAL	20	100	67	100
Q.7 MOST DIFFICULTY WITH				
top	11	55	36	55
bottom	3	15	5	7
right	3	15	9	14
left	2	10	5	7
no difficulty	0	0	11	17
TOTAL	19	100	66	100
Q.8 CHARACTERS WERE				
too fuzzy	5	26	32	49
too small	1	5	2	3
lacked contrast	13	69	20	30
no difficulty	0	0	12	18
TOTAL	19	100	66	100
Q.13 MOVE PROJECTOR				
closer to screen	12	60	28	42
leave in same position	5	25	36	54
farther from screen	3	15	3	4
TOTAL	20	100	67	100

TABLE 5. COMPARISON OF SUBJECTS REPORTING CONSIDERABLE DIFFICULTY READING DISPLAY WITH SUBJECTS REPORTING NO DIFFICULTY

	SUBJECT LOCATION					
	FAR RIGHT				FAR LEFT	
	1	2	3	4	5	
POSITION - FRONT	-	2	-	1	-	3
- MIDDLE	4	1	1	3	-	9
- BACK	3	-	-	2	1	6
- TOTAL	7	3	1	6	1	18

TABLE 6. INTERACTION OF SEATING ANGLE WITH DISTANCE
(ONLY SUBJECTS REPORTING DIFFICULTY READING DISPLAY)